

MORE PLANT STUDY: FEWER PLANT NAMES

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NATURE produces infinite variety. Man (the taxonomist) desires, imagines, and describes uniformity. Therein lies perpetual confusion and conflict. Before obvious differences can be evaluated, we need to understand their nature, extent, and probable causes. The writer can speak definitely only of the genus *Salix* (willows).

FOUR MAJOR CLASSES AND CAUSES OF VARIATION

Four major classes of variation occur normally on shrubby and/or arborescent willows, and to a lesser degree on prostrate and creeping species. A: The same organ, on one part or on different parts of a single plant, normally presents striking variations. The pattern is permanent but the expression is modified by environmental conditions. B: An individual organ usually or often shows great variation during the course of a season or a year. These variations are the direct result of the advance from spring to summer, to autumn, and back to spring again, but their expression will be modified by differing conditions in differing seasons or years. C: Plants of a single species, growing under obviously different conditions of local environment, frequently present large variations from spot to spot. While presumably environmental effects, these variations may include the hereditary differences of Class D also. D: Two or more individuals, growing under apparently identical conditions of local environment, frequently display obvious differences. These should be hereditary variations, if the environments actually are identical, but are influenced somewhat by the age of the plant.

A. VARIATION OF AN ORGAN ON A SINGLE PLANT

The Individual Leaf. As the leaf emerges from the bud-scale, the outer or apical portion broadens first. This broadening progresses toward the base. If the nutrient supply is reduced by competition farther out, before growth of the leaf is completed, the lower (first developed) leaves may never finish normal basal expansion. Leaf-bases may remain cuneate, acute, or rounded, which should have become acute, rounded, or cordate, respectively. The tip also may fail to elongate, leaving the apex obtuse or acutish when it should have been acute or acuminate.

Different Leaf Forms on a Single Twig. On any given twig, there will be three successive and intergrading sizes and shapes of leaves, occupying basal, central, and apical locations on the twig. The basal leaves in general will be smaller, narrower at base, and broader and blunter at apex than the

central leaves. The apical leaves will tend to be larger, broader at base, and more acute or acuminate at apex than the central leaves. The central leaves, therefore, are somewhat intermediate between the basal and apical leaves in size and shape, just as they are intermediate in position and time of development. In general, therefore, there is a steady progression in leaf size and shape from the base (first developed) to the apex (last developed) of the twig. This progression tends to recapitulate the developmental history of the individual leaf. These facts hold, no matter what the normal shape of the leaf may be.

Four Types of Twig Per Plant. Normally there are three, and sometimes four, types of leafy twigs produced successively during each season. Type *a* is represented by the short twigs which develop simultaneously with the fruits, from lateral leaf-buds on the fruiting twigs. Type *b* is represented by the longer and somewhat vigorous twigs which develop, after fruiting is over, from apical buds on the fruiting twigs. Type *c* is represented by the vigorous shoots which develop later from buds on older wood, after the food-drain of fruiting is over. Type *d* is represented by the luxuriant shoots (water sprouts) which sometimes develop on trunks and/or roots in late summer. Schneider (10, p. 9-10)¹ discussed parts of this problem briefly in 1918, but in somewhat vague language; the writer (4) more fully in 1943.

On each of these four successive types and sizes of branchlets, there will tend to be the same progressive shift in size and shape of leaves, from base to apex, as was described above. But in addition to this normal progression, all the leaves on type *a* tend to be shorter and relatively broader, all those on type *b* tend to be intermediate, and all those on type *c* tend to be larger than on the others. These changes, like those on a single twig, probably represent the more abundant food supply and more favorable temperatures as the season advances. Fruiting limits nutrients available to early shoots and rapid elongation of a summer twig may cause food to bypass the basal leaves. Sometimes the apical leaves on late-produced type *c* twigs do not attain full size because of drought or cold in autumn. The leaves of all three groups on the sprouts of type *d* often are enormous in size and more or less different in shape, but there will be the same general progression from base to apex of sprout. Because of the variations just discussed, the writer often takes from three to six or seven sheets from a single plant.

B. VARIATION OF AN INDIVIDUAL ORGAN DURING THE YEAR

Twig, Bud-scale, and Branchlet Changes. These organs, as well as petioles, may change greatly in color and clothing during the successive seasons of a year, and the twigs during successive years, as they become 1-year and 2-year branchlets. These changes are caused by plant reactions

¹ Numbers in parentheses refer to "Literature Cited" at end of paper.

to sun, temperature, rain, etc. In general, they are greatest in plants in full sun and on those organs in direct sunlight.

In general, colors darken as the season advances. Original yellows, light greens, and light browns become varying shades of darker brown to blackish. As new twigs are produced during the summer, each must pass through these changes. In a few species, as *S. amygdaloides* and *S. lutea*, the yellow is permanent. In parts of Alaska and Yukon, as noted by Dr. Setchell, the abundant *Salix Barclayi* colors the spring landscape with its bright yellow twigs and the very light yellowish green of the unfolding leaves. But in the herbarium, and the manuals, the branchlets are blackish. The occasional bits of still-yellow epidermis are neither large enough nor numerous enough to be conspicuous. The same facts are true of *S. monticola* in the Rocky Mountains, according to the continuing observations of Professor Ernest C. Smith. After going through the press, the twigs, with rare exceptions, are like those of *S. Barclayi*. By extremely careful drying, much of the yellow color may be retained.

Twig, bud-scale, and branchlet hairiness is one of the most variable characters of the vegetative organs of willows, and presumably of other plants as well. It is highly external, being a product of the epidermal cells and therefore greatly influenced by temperature, sun, etc. Its primary function probably is protection of young tissues against sun scald. In many species, the seasonal shoots (hornotini) are more or less densely puberulent, pubescent, or tomentose. This covering may be present in lesser degree as these shoots become 1-year (annotini) and 2-year branchlets in succeeding years. In other species, the seasonal twigs may be completely glabrous and remain so in later years. All this sounds simple, but. . . .

The conspicuous pubescence of a new shoot may wear off gradually during autumn and winter, leaving glabrate to glabrous twigs in spring. Many species shed the epidermis from the branchlets in spring or early summer and, of course, the hairs go with it. In such cases, there usually are "armpit" areas on the twig, behind buds or lateral twigs, where the epidermis was not deciduous and tell-tale remnant pubescence may be found. Hairiness of bud-scales usually parallels that of twigs.

Twig and bud-scale pruinosity occurs on such species as the western *S. irrorata*, *S. Lemmoni*, and *S. subcoerulea*, the northeastern *S. pellita*, and the European *S. daphnoides*. This waxy exudate is more external and less stable than the wax causing glaucousness of leaves, and therefore is more temporary in nature. It may be washed off by rain or snow, gradually removed by slow weathering, or completely discarded with peeling epidermis (5). Many other species, northern and arctic, occasionally show some pruinosity of bud-scales, branchlets, or even capsules, with organ frequency in the order named. This has little diagnostic value, because of infrequent and irregular occurrence, confinement to a small part of the eligible organ surface, or quantity so dilute as to be distinguished only with difficulty.

Leaf Structure. Leaves and stipules may change greatly in degree of gland-presence, serration, and vein-prominence during the season, as they develop from juvenile to full-sized, to mature, and to senescent condition. Glands may drop off and serratures may enlarge. Many species have normally entire leaves but scarcely one of these will fail to show some serration on vigorous apical leaves. Venation often becomes increasingly prominent with age in some species, under conditions little understood. Unusual specimens become varieties or forms under such names as *venulosa*, *marginata*, *reticulata*, etc.

Leaf Hairiness. The leaves of many, probably most, species of willows are more or less hairy, on one or both surfaces, while they are unfolding. If densely hairy at first, they become less so through expansion of area, even if no hairs drop off. For those kinds not permanently hairy, the rate of hair fall varies with the kind, the environment, and the individual, just as in the human races. Those which have a natal coating of very long hairs on the under-surface usually lose them quickly (*S. anglorum*, *S. laevigata*), and persistence is greatest at the tip. Those with shorter hairs are likely to lose them more slowly, first from the leaf-surface, then successively from the larger veins and outer midrib, and finally, if at all, from the lower midrib and petiole. Some arctic species remain ciliate on the margins. Species with permanently hairy leaves are found more commonly in cool and cold climates than in dry and hot areas, but there are exceptions. The hairs normally become thinner with age and some individuals in nearly all species lose most or all of the hairs by autumn. From this, we have varieties and forms named "glabra," "glabrescens," "tonsa," etc. How about naming balding humans?

Leaf Glaucousness. The glaucousness or glaucosity of the lower surface of the leaves of many species of *Salix* are valuable and usable taxonomic characters, if botanists understand the chemistry and physiology of this expression. It is the result of a waxy secretion, and the time of appearance and quantity produced seem to be governed by physiological processes. In species which normally are heavily glaucous, the whitening of the under-surface is apparent when the leaves begin to unfold, as in *S. longipes*, *S. laevigata*, *S. discolor*, etc. In species normally less densely glaucous, the color may not become visible until the leaves are half-grown, as in *S. cordata* and some relatives, *S. sericea*, *S. lasiolepis*, etc. In still others, as in the western *S. lasiandra* and the introduced *S. fragilis*, the under-surface may remain pale green until the leaves are full-sized.

To add to taxonomic troubles, this white waxy substance is destroyed by too rapid or too hot drying of fresh specimens. This occurs often when electric driers are used. The glaucous condition cannot be restored. The blades remain permanently "green on both sides" and cannot be identified by the usual keys.

Floral Organs, such as aments, peduncles with their bracts or leaves, flower-scales, glands, stamens, and capsules with their pedicels and styles

and stigmas, likewise change greatly as they develop from the juvenile stage to maturity. Not only this, but the relative lengths of any two organs may change because some start earlier, or elongate faster, or continue growth longer than others. Some of those maturing quickest (glands, styles, and stigmas) may even shrink after maturing and so change relative dimensions. Yet some recent taxonomists still describe floral organs in terms of relative lengths, without regard to the degree of maturity of the two organs compared, as "gland equalling the pedicel," "styles $\frac{1}{2}$ as long as pedicel," or "scale twice as long as the gland," etc. Such statements often are wholly misleading for taxonomic purposes.

There often is 100 percent variation in length of floral organs (except capsules) in a single ament, and it is not regular and progressive from base to apex or the reverse, although pedicels and scales tend to be longest at the base of aments. Scales are especially puzzling, as they usually are relatively short and broad in the opening ament and there is relatively little uniformity at maturity.

Scale Color and Hairiness. Scales in several Sections of *Salix* are pale yellow and deciduous. They may become pale brown in weathering or drying. In two Sections (*Glaucæ*, *Rostratæ*) with persistent scales, these are yellowish or light brown and may weather or dry to a medium brown, especially at the normally visible apex. In other Sections, the scales usually are dark brown to black and remain so, although light brown scales occur occasionally.

Flower-scales of most willows normally are hairy, primarily for insulation and protection of the subtended organs. In most species, these hairs tend to drop off gradually, especially from the outer surface. Some scales become glabrate outside, others remain hairy. Some northern and arctic species, however, have scales glabrate or glabrous from the beginning (*S. pyrifolia*, *S. leiolepis*, *S. chlorolepis*).

Capsule Hairiness. Many species have permanently hairy capsules and almost never is a plant found whose capsules have become entirely glabrous in age. Only rarely do these species have varieties with normally glabrous capsules. Exceptions are *S. brachycarpa* var. *glabellcarpa*; also the species *S. chlorolepis*. In Sections *Commutatæ* and *Chrysanthæ*, having some species with permanently hairy capsules and other species with normally glabrous capsules, the latter species are likely to have varieties with more or less hairy capsules (*S. Barclayi* var. *hebecarpa*, *S. commutata* var. *puberula*, *S. Hookeriana* var. *tomentosa*). Hairy-capsuled species in these sections do not have glabrous-capsuled variations. In some Sections (*Nigræ*) with normally glabrous capsules, variations with pubescent capsules may occur (*S. Gooddingii*, *S. Humboldtiana* var. *Martiana*), but the hairs usually are deciduous before capsule maturity.

C. PLANT VARIATIONS CAUSED BY DIFFERING LOCAL ENVIRONMENTS

Every farmer and farm boy know the difference in height and color of

maize plants in different parts of a single rolling clayey field: stunted and yellow plants on the dry and stony hilltops, because of lack of water and food; normal green and healthy plants on the lower slopes because of more water and sufficient fertility; deep green and luxuriant plants on the flat, fertile, well-watered bottoms, through exceptionally favorable conditions; marked differences in the size and color of plants and all of their organs. Yet all grew from the same lot of seed, in the same season. The ear-size of all three groups will be proportional to plant-size, but the hereditary characters, kernel-row number and kernel shape and color, will not be changed by these local influences.

Wild plants respond in the same way to moisture and fertility differences in rich, well-watered alluvium, drier second-bench, sterile sand or gravel bars or sand dunes, and dry and barren hilltops, wherever the same species gains a foothold in several or all of these habitats. In the drier and more sterile locations, the plants will be depauperate and the vegetative and many of the floral organs will be reduced accordingly. In the average or normal habitats, the plants will be normal and their organs will tend to be of average dimensions. Where moisture and fertility are high and temperatures favorable, as on a mid-latitude alluvial flood-plain, the plants will be luxuriant and their organs will respond by tending to reach sizes well beyond the normal. But these differences, however striking the extremes, do not make the different plants into "new" species or varieties. They should be labelled for what they obviously are: "depauperate," "normal," and "luxuriant." If conditions were changed, the plants would change also.

Conditions producing extreme heat locally may result in striking changes in affected plants, such as depauperate growth of plant and parts, extreme hairiness, etc. Such conditions occur on sandy and rocky situations, as bars, blow-outs, dunes, quarries, out-crops, etc., where extreme radiation of heat may occur. In the same way, extreme shade may cause remarkable differences in size, shape, thickness, and color of vegetative organs.

When the leaves of certain species of willows (*Longifoliae*) are eaten off in summer by sawfly larvae, a full new crop of much smaller leaves is likely to appear. They usually will be densely white-hairy, probably a reaction to midsummer temperatures much higher than those prevailing when leaves normally are unfolding. These plants are very deceptive in appearance, looking like something very different from what they really are. Usually, however, some attached fragments of the original and much different leaves may be found and the deception unmasked.

D. ACTUAL HEREDITARY DIFFERENCES

We see differences between individuals of the same species, even when growing under apparently identical conditions. If the conditions actually are identical, then these differences should be real and hereditary. The number of such differences, the regularity of their association, the uni-

formity of their expression, and the degree of their departure from the norm of the species will be factors in determining whether any of the plants warrant recognition as different taxonomic entities.

These basic facts can be verified only by a study of numerous plants in the field, in different geographic areas of the species range. Having in mind, however, the above-presented facts regarding variations, much may be deduced from a study of abundant and widely collected herbarium material. In the case of shrubby and arborescent plants, a herbarium specimen is but a fragment at best. Because, in *Salix* for example, the two sexes are on separate plants, it is a fragment of only one half. A series of specimens, unless specially collected, is only a series of fragments of the halves. And even if an extensive series came from plants which were practically identical, they would have been collected at different times in the season, at different periods of development, and from different portions (expressions) of the plants. And no two plants are practically identical. Some will be undeveloped or juvenile, other full-sized, still others mature. Unless the whole series is quite extensive, therefore, no satisfactory large-scale comparison is possible.

Furthermore, the average herbarium labels carry few or none of the data which might enable the taxonomist to determine if local environments (habitats) actually were similar, let alone identical. For these reasons, the student cannot be completely sure whether the differences observed on specimens are actual and hereditary or the effects of local environmental influences, either permanently or temporarily prevailing. To name new species or varieties, therefore, from one or a few fragmentary specimens under such conditions is to shun personal responsibility and to leave the real labor for another to perform later.

COMBINING PRECEPT AND EXAMPLE

Precept is easy and often abundant. Example is difficult and often proportionately rare. Certain important precepts have been set forth above. Summarized, they read: "Know what to expect from plants growing under different conditions, and why."

Below are outlined two quite different methods of studying botanical material for taxonomic purposes. In either case, it is assumed that the material represents, or is supposed to represent, a given species and its varieties, together with closely related species of possibly doubtful validity, and species and/or varieties currently held to be synonyms.

TWO METHODS OF STUDYING TAXONOMIC MATERIAL

The first method is to obtain the largest possible collection of specimens representing all of these real, supposed, and/or unadmitted entities. Better still, study large numbers of living plants in the field, in different habitats in various geographic areas of the total range. Even better yet, do both. Because adequate field study is difficult or impossible for many students,

chief dependence must be put on herbarium material. In any case, the specimens should be sorted out by geographic areas, without regard to the names which have been applied to them previously. Whether living or dead, complete or fragmentary, they are studied critically for similarities and differences, and the differences are analyzed as to nature, causation, and value, on the basis of the previous precepts. All this is without cross-reference to the previously published descriptions of the species and varieties involved.

This is the centripetal method, working from the outside in. It gets to the heart of the matter. It assumes the possibility of specific unity of the material. It challenges the mind to discover if there are differences, and to prove whether discovered differences are inherent or merely the effects of local environment. It says: "Find out what there is, — then what others thought there was." It keeps the mind free from prejudice while this is being done.

The second method is to study, successively, the descriptions and the cited or supposed material of each of the named species and varieties known or suspected to belong within the broad limits set. When one such has been studied and segregated, another is taken up, and so on until all have been covered. This is the centrifugal method, working from the inside out. It flies out from the center in all directions. It assumes differences, consciously or unconsciously, because others have done so. One is following a blazed trail instead of blazing one. Others have applied different names, have emphasized different characters or appearances, and have made comparisons to prove that significant differences exist. There is an internal pressure to verify what others have found or decided. All of this influence is present in addition to the urge to father more entities, new or resurrected, especially just before a new edition of a manual.

STANDARDS FOR TAXONOMIC WORKERS

At present there are no professional standards or requirements for taxonomic workers. Each is a law unto himself, although their products affect tens of thousands of students and teachers, either as a help or as a burden. This lack of standards is responsible in part for the lack of respect in which this profession is held. If embryo taxonomists were required to go out and measure and record the range of variation in organs on a single large living plant or on numerous smaller plants of several species, they would return both tired and amazed. If they were required to follow the progressive variation of all organs on a plant through all of the seasons of even a single year, they would become both enlightened and humbled. Knowledge, with amazement and humility, is an excellent foundation for future taxonomists.

Such procedure would insure fuller and more accurate descriptions of plants, in journals and in manuals. With that, more people would know more about more plants. It also would curb the present tendency to

consider every observed variation as a novelty to be named. This would mean reduction in the flood of synonyms, so expensive of time and money. It would keep systematic botany simpler and taxonomists more respected. The end result would be more time and money spent on knowledge of plants and less on knowledge of names. Many years ago, when a great university inaugurated a program of "humanizing instruction at the freshman level," a non-botanist said to the president: "I have seen a miracle on this campus." "What have you seen?" he was asked. "I have seen a class in botany out of doors looking at a plant," was the reply.

Many new species and varieties have been based on these major developmental and environmental variations. This will continue unless there is better teaching. Even a single leaf from each of the three series on a single twig, or three from each of the four twig-types on a single plant, may become the type of supposed new entities. A paleobotanist may do just that because, to him, a leaf is a determinable and usable unit. If two or more leaves are markedly different, they must represent, of course, different entities. Let us use a little common sense in this matter of basing novelties on such variations. Let us not make another 1000 so-called species of *Crataegus*, or of any other genus, with the type specimens of three species taken from one tree.

All are familiar with the often striking differences between the children of the same human parents. All had exactly the same ancestors, but some are short and some tall, some slender and some stout, some fair and some dark, and some quick and some slow. But we do not insist on naming new varieties and forms based on these differences. Nor do we base new species on the differences between the juvenile and the adult human organism.

EXAMPLE: EXIT *SALIX MISSOURIENSIS* BEBB

Turning now from precept to example, there is set forth an example of the results obtained when variable taxonomic material is studied by the centripetal method. Some may not agree with the conclusions reached. Conclusions in taxonomy always must rest on personal judgments. But it is hoped that there may be agreement as to the value of the method used.

In 1867, Andersson (2, p. 159), the Swedish salicologist, in a monographic discussion of *S. cordata* Muhl., arranged *S. rigida* Muhl. as a subspecies and thereunder created a new variety, *vestita*. This was based on a single juvenile specimen collected by Neuwied at Ft. Osage on the Missouri River (not far from present Kansas City). Of it, Andersson says: *ramis crassiusculis, annotinis tomentosus; foliis novellis plus minus dense sericeo-tomentosis, lucidis, integris; amentis ♀ crassis praecocibus omnino nudis, rachi dense villosa, squamis sat longe pilosis, capsulis e basi sat crassa conicis stylo haud elongato apiculatis.*"

In 1868, Andersson (3, p. 252) presented var. *vestita* again, this time as a seventh variety of subspecies *rigida*. The description is shortened and

the reference to thick branchlets omitted. The plant would pass for *S. cordata*, except perhaps for the stout aments and the long-haired scales.

In 1895, Bebb (6, p. 373) decided to raise Andersson's variety to specific rank but, because of the earlier *S. vestita* Pursh, he named it *S. missouriensis* and designated it as "n. sp." Needed parts of his long description will be given in the discussion of plant and organs which follows. He was somewhat doubtful of the validity of his species, however, and said:

"For one of the Cordatae, the extraordinary height and size of trunk attained by this Willow, the repeated [reputed?] durability of the wood for fence-posts, its early period of flowering, together with the technical characters above given, would seem to amply warrant its elevation to the rank of a valid species. At all events, as such, it is more likely to receive that further study and criticism which will determine its true status, than if left as a doubtful variety within the limits of such a polymorphous species as *S. cordata*."

Several items in Bebb's description and discussion require comment. If the comments appear derogatory of his judgment, let us remember that he always had been careful and conservative, that here he apparently was grossly misled by others on two important points, and that he was aged and failing (he died in 1896).

In the past six years, the writer has studied more than 1000 sheets of *S. cordata* and *S. missouriensis* in his own herbarium, the U. S. National Herbarium, and that of the University of Nebraska. Increasing Nebraska collections by Dr. Walter Kiener soon convinced him that *S. missouriensis* was not a distinct species but at most only a variety (var. *vestita* Anderss.). Since the preparation of the above discussion of the nature and causes of variation, and the appearance of Dr. Fernald's recent discussion (7, p. 27-28) in *Rhodora*, most of this material has been reviewed for data on the points at issue, with the further conclusion that var. *vestita* is not even a valid variety, for the reasons given below.

Polymorphism. Bebb refers to *S. cordata* Muhl. as polymorphous. It is. All willows (and other plants) are, although perhaps not in just the sense Bebb meant. That polymorphism is the thesis of the present paper. *S. cordata* is an excellent illustration of the principles set forth herein. It has a range (with var. *vestita*) of almost 2000 miles east-west and some 1100 miles north-south, with a corresponding diversity of climate, soils, and local habitats. It is a large enough shrub to permit expression of the maximum variation on a single plant.

Height and Diameter. Bebb describes his species as a tree "thirty or forty, or even fifty, feet in height, trunk ten or twelve, rarely eighteen inches in diameter." Sargent, in 1896 (9, p. 137), repeated these dimensions and later manuals have repeated the height. Where did Bebb get this record of tree-like height for a shrubby or arborescent plant? He had never seen it growing, but refers to collections by Sargent and Bush from Courtney, Jackson Co., Mo. There are three true tree willows which

occur along the Missouri in that area, namely, *S. longipes* (var. *Wardii*), *S. amygdaloides*, and *S. nigra*. All three may attain the height, and rarely the trunk diameter, recorded by Bebb. It seems almost certain that, if Sargent or Bush furnished the height data, they included plants of one or more of these tree species when estimating maximum height and diameter. *Salix longipes*, especially, bears a deceptive resemblance to luxuriant *S. cordata* (var. *vestita*).

Most collectors do not record heights of plants collected. In the Bebb Herbarium at the Chicago Natural History Museum are three specimens collected by Bush in 1892 along the Missouri River in Jackson Co., Mo. It may be that Bebb's species was based on these, but no heights are given on the labels. One is said to be a tree 12 inches in diameter and two are called small trees, with 10- and 6-inch diameters, respectively. In 1895 and 1896, Dr. Glatfelter collected at least 31 specimens of var. *vestita* (distributed as *S. cordata* × *S. sericea*) in and around St. Louis, Mo., the labels giving heights and often diameters. Of these 31, only ten reached 20 ft. or more. Three of these ten reached 25 ft., with diameters of 5.5-7 inches. Only one was 30 ft. high, with 7-inch diameter. These taller plants mostly had single stems, dividing low. Other collectors record heights from 15 to a maximum (Ia.) of 27 feet. It may be that Sargent was responsible for the exaggerated height record. In any case, the Jackson Co. plants were from conditions of moisture, fertility, and climate which make all vegetation remarkably luxuriant. The eastern plant has a general height of 10 to 20 feet, with the maximum somewhat more.

Branchlet Size and Hairiness. In 1867, Andersson (2) described very stout twigs, but in 1868 he dropped the phrase. Bebb said: "one-year-old twigs stout." Actually, twigs show just about the same stoutness from the Great Plains to the Atlantic.

Hairiness varies in exactly the same ways throughout the entire area. It is fixed in many minds that the vegetative parts of *S. cordata* are glabrate or glabrous and those of var. *vestita* are hairy. The study of some 1000 specimens shows hairiness (puberulence, pubescence, and/or tomentum) to be practically universal. The white-pubescent seasonal twigs occur in Lower Canada, New England, the Potomac-Shenandoah Valleys, the Appalachians, and the Lake States, as well as in the Mississippi-Missouri Valleys. The denser the twig pubescence, the more frequently it is associated with pubescence or bud-scales, petioles, midribs, and sometimes stipules and young blades. Glabrate to glabrous yellowish seasonal or 1-year twigs were more common westward in the drier areas, but many 1-year and 2-year twigs glabrous in spring showed tell-tale remnant pubescence behind buds and lateral twigs. The long season and high summer temperatures of the lower Missouri are favorable to denser pubescence of twigs.

Leaves. Andersson's type had only very young leaves. Bebb describes the leaves as:

“ . . . lanceolate or oblanceolate, five to six inches long, from one to one and a half inches wide, cuspidate-acuminate, narrowed from above the middle toward the acute or rounded (but not truncate or cordate) base, at first more or less clothed with silky hairs, soon smooth and dark green above, except the downy midrib paler, but not glaucous beneath, margin glandular-serrate; petioles downy, half an inch long, . . .”

These statements regarding leaf-length, leaf-base, and glaucousness are not true for either the western or eastern plants. The leaves of “*S. missouriensis*” by no means average 5–6 inches long. On fruiting twigs and many early seasonal twigs, the leaves are 3–4 inches long and 0.7–1 inch wide. On more vigorous seasonal shoots, they reach 5–6 inches long by 1–1.5 or 1.8 inches wide.

In the eastern area, the leaves average about the same in size, on comparable twigs, as in the western. Relatively large leaves, up to 5.5 inches long and 1.4–1.7 inches wide, are found frequently from Lower Canada and New England southward. Westward, the leaves tend to average narrower. One specimen from Maine has blades 6.5 by 1.4 inches, while specimens from Quebec, Vermont, and New York run to 6 by 1.5–1.7 inches. Petioles on leaves in the Northeast range from 0.5–1 inch long. In Virginia, leaves range up to 6 by 1.75 inches; in West Virginia to 5 by 1.5 inches. None larger have been found in the Missouri River area, on either supposed species. Specimens with shorter but relatively broad leaves occur sparingly throughout and are likely to be associated with densely pubescent shoots, bud-scales, petioles, midribs, and sometimes blades.

In the material assigned to *S. missouriensis*, the bases of the larger leaves commonly are truncate and some are strongly cordate (*Glatfelter 13*), Bebb’s note to the contrary notwithstanding. The range for leaf-base shape is exactly that for accepted *S. cordata*. In both eastern and western plants, mature leaves are glaucescent to glaucous beneath, although the color may not develop until the leaves are nearly full-sized. The leaves on autumnal collections of both plants usually are strongly glaucous.

Early Flowering. One of the distinctive characters asserted for *S. missouriensis* was its early flowering. Bebb quotes Bush as follows: “The aments usually open about the first of February and have passed out of bloom by March 1st, whereas those of *Salix cordata* do not appear till the first week in April.” This is a difference of about two months, if true, but it does not happen to be true. Let Bush’s own collections speak. In 1896, he collected *S. missouriensis*, nos. 448, 464, 470, 475, and 480, at Courtney, Jackson Co., Mo., between April 11 and 19, the first spring after Bebb’s publication. These five specimens, in U.S. Nat. Herb., bear just-opening aments, not-yet-flowering aments, flowering aments, and young fruiting aments, all 10 weeks after flowering should have started and 6 weeks after it should have ended, according to Bush. This was not confined to 1896. Number 6552 has 3-inch pistillate aments in flower on April 15, 1912, as delayed as those of 1896. Number 7719 has sessile 2-inch aments in flower on March 24, 1916, seven weeks after it should have begun and 3

weeks after it should have ended. The Glatfelter specimens from St. Louis were in bud from March 25 to April 7; in flower from March 27 to April 12; and in young fruit from April 17 to 24.

Ament Length and Laxity. Bebb described the aments as precocious, sessile, dense-flowered, the staminate oblong, 1.5–2 in. long by 0.5 in. wide, the pistillate lengthening to 3 in. and becoming more or less lax in fruit. Sargent (9, p. 137), in 1896, adds another inch gratuitously ("3–4 inches long"). The maximum (not average) is 3 inches. Abundant material shows that the pistillate, at flowering, are 1–2 in. long, lax, borne on short (0.5 cm.) bracted peduncles. In fruit, the aments become 1.5–2.5 or rarely 3 inches long (*Bush 6552*) and very lax, and the peduncles become up to 1 cm. long, with small leaves. Laxity is a function of rachis and/or pedicel elongation. The pedicels become 1.5–2.5 or rarely 3 (*Bush 475*) mm. long, the capsules 6–7 mm. and the styles 0.5–0.6 mm. long. Eastern material shows aments up to 2.5 inches long from Lower Canada, Massachusetts, and New York, and one Massachusetts specimen (*Forbes 563*) has aments up to 3 in. (7 cm.) long. Pedicels up to 2–2.5 mm. are frequent in the east and 3-mm. pedicels occur in New Hampshire (*Rand & Robinson 652*) and Massachusetts (the Forbes plant with 7-cm. aments).

Scale Length and Hairiness. Both Andersson and Bebb stress the length of the flower-scales and of their densely investing hairs. Both were studying specimens from luxuriant plants whereon most organs were larger than average. Also, the resulting ament laxity enabled the usually partly hidden scales to be easily seen. These facts are true also of luxuriant plants in the eastern area.

Capsule Length. Neither Andersson, in describing var. *vestita*, nor Bebb, in creating *S. missouriensis*, mentions capsule length, so apparently they saw no difference from that of *S. cordata*. *Salix eriocephala* Michx., which Fernald says is the same as *S. missouriensis* Bebb, is staminate. Andersson completely misinterpreted *S. eriocephala* from beginning to end (1, 2, 3), so that his statements about capsules obviously apply to those of other species. Fernald (7, p. 27), however, says: ". . . , the very large precocious aments and long (up to 1 cm.) capsules having deceived those who did not consider the other characters, . . ." Fernald gives no authority for this assertion of unprecedented capsule length, an increase of some 43% over the maximum recorded.

Measuring the capsules on numerous luxuriant specimens from the Missouri flood-plains, the normal length is found to be 5–6.5 mm., with a few reaching a maximum of 7 mm. long. Outside the most favorable habitats, the capsules also average 5–6.5 mm. but never reach 7 mm., so far as seen. The capsules of accepted *S. cordata* normally run to 6 mm. long and occasionally to 6.3 mm.

Summary of "S. missouriensis." The great height and diameter ascribed are not proved and remain extremely doubtful. The tomentum of twigs is shared by many eastern specimens, although Missouri-Mississippi Valley

conditions are conducive to extreme hairiness. Long leaves and truncate to cordate bases occur throughout the entire area. The reported extremely early flowering is disproved by the records. Expanded pistillate aments are not sessile and naked. The long aments, scales, scale hairs, and pedicels are matched by those on equally luxuriant eastern specimens. The long capsules asserted by Fernald just cannot be found on any plants. "*Salix missouriensis*" is merely the luxuriant expression of *S. cordata* Muhl. under favorable conditions of temperature, moisture, and fertility.

"*Accurate and Cautious Salicologists.*" Fernald (7, p. 29) designates the Swedish salicologist, N. J. Andersson, as "the most accurate student ever to work on *Salix*, . . ." He further said (7, p. 31) ". . . it is . . . the highest of honors to get near the limited group of most cautious salicologists with Nils Johan Andersson!" Let us consider just what Andersson did with *S. eriocephala* Michx. and *S. cordata* var. *vestita* Andersson, which Fernald states to be one and the same (Section *Cordatae*).

In 1858, Andersson (1, p. 117) placed *S. eriocephala* in a group with *S. lasiolepis* and its relatives (*S. Bigelovii*, *S. irrorata*), all of Section *Lasiolepes* (related to *Cordatae*), and threw in his wholly unrelated *S. Coulteri* (closest to *S. sitchensis*, Section *Sitchenses*) for good measure. *Salix cordata* is not mentioned. In 1867 (2, p. 85) and 1868 (3, p. 225), he arranged *S. eriocephala* as a variety of *S. discolor* (Section *Discolores*), even more distantly related than *S. Coulteri*. In all three papers, his extended discussion contains repeated expressions of uncertainty and repeated comparisons with many and diverse species, but always with *S. discolor* and its relatives, to which it is least related.

In 1867, Andersson (2, p. 159) created his hairy-twigged var. *vestita*, specifically identical with *S. eriocephala* (fide Fernald), and assigned it to *S. cordata*, even noting its glabrous capsules. But he compared it with *S. discolor*, which has glabrous twigs and pubescent capsules with quite different styles and stigmas. This treatment was repeated in 1868 (3, p. 252), without the reference to *S. discolor*.

Andersson, in short, dealt with two specimens of an identical entity, collected in the fertile flood-plain within 400 miles of each other. The pistillate he made a variety of *S. cordata*, where it belonged, but compared it with the unrelated *S. discolor* in spite of its hairy twigs and glabrous capsules, the opposite of *S. discolor*. The staminate plant he first assigned to the *Lasiolepes*, close to *Cordatae*, but then shifted it to *S. discolor*, a completely unrelated species, and invented a pistillate plant to justify that disposition.

Many similar acts by Andersson have been cited by Bebb and others and many more remain uncited. When Fernald assigned to the capsules of *S. eriocephala* a length of 1 cm., he perhaps achieved a certain nearness to Andersson in accuracy and caution.

LITERATURE CITED

1. ANDERSSON, N. J. Bidrag till kännedomen om de i Nordamerika förekommande pilarter (Salices). Oefvers. Kon. Vet.-Akad. Förh. 15: 109-133. 1858. Printed simultaneously as: *Salices Boreali-Americanae*. A synopsis of the North American Willows. Proc. Amer. Acad. Arts & Sci. 4: 50-78. 1858 (with the introduction in English and footnotes by Asa Gray). Commonly found as a reprint, pp. 1-32.
2. ANDERSSON, N. J. Monographia Salicum. Kon. Svensk. Vet.-Akad. Handl. 6: i-iv, 1-180, *pls.* 1-9. 1867.
3. ANDERSSON, N. J. Salicineae, in De Candolle, Prodrum 16(2): 190-331. 1868.
4. BALL, CARLETON R. Illustrating plant organs for taxonomic purposes. Castanea (Jour. So. Appal. Bot. Club) 8: 67-71. 1943.
5. BALL, CARLETON R., and KIRK WHITED. Pruinose branchlets and *Salix Lemmonii* Bebb. Amer. Jour. Bot. 12: 91-96. 1925.
6. BEBB, M. S. Notes on some arborescent willows of North America.-II. Gard. & For. 8: 372-373. 1895.
7. FERNALD, M. L. Technical studies on North American plants, II. Difficulties in North American *Salix*. Rhodora 48: 13-16, 27-40, *pls.* 995-1006. 1946.
8. MICHAUX, ANDREAS. Flora Boreali-Americana 2: (*Salix*) 225-226. 1803.
9. SARGENT, CHARLES SPRAGUE. Silva of North America 9: 137-138, *pl.* 480. 1896.
10. SCHNEIDER, CAMILLO. A conspectus of Mexican, West Indian, Central and South American species and varieties of *Salix*. Bot. Gaz. 65: 1-41. 1918. (pp. 9-10).

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